Journal of Orthopedics Research and Rehabilitation

Original Article

DOI: 10.51271/JORR-0003

Mid-term results in adult humeral fractures with titanium elastic nail fixation versus plate and screw fixation and locking intramedullary nailing

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Submit Date: 22/12/2022 **Accept Date:** 27/01/2023

ABSTRACT

Aims: To compare plate-screw fixation, intramedullary nailing (IMN), and titanium elastic nailing (TEN) as a new fixation method with respect to nonunion, complication rates, and functional outcomes in the repair of adult humeral shaft fractures.

Methods: A total of 38 adult patients who were treated due to humeral shaft fracture at our clinic and were followed for minimum six months between January 2012 and January 2015 were retrospectively analyzed. Age, sex, fracture etiology an length of hospitalization were recorded. Fractures were classified according to the Association for Osteosynthesis(AO) classification. Nonunion rates as assessed by X-ray during visits, angulation, shoulder, elbow and hand disability scores were evaluated using the DASH, Mayo Elbow and UCLA Shoulder scoring, and Stewart Hundley criteria.

Results: There was no significant epidemiological difference between the groups. The length of hospitalization was lower in the TEN group. There was no significant difference in nonunion rates and functional scores according to the type of treatment. Angulation rate was slightly higher in the TEN group. The effect of angulation on functional score showed no influence on the functional status. The three treatment types mostly achieved excellent and good outcomes.

Conclusion: Our study results suggest that TEN seems to be a good alternative treatment in eligible patients with humeral shaft fractures considering complications of other treatments. However, we believe that further, large-scale, randomized-controlled, prospective studies with longer follow-up duration are required to confirm these findings and to establish a definite conclusion. Level of Evidence: Therapeutic Level III.

Keywords: Humerus, diaphyseal fractures, TEN

This manuscript has been oral presented in 6th International Hippocrates Congress on Medical and Health Sciences as an full text and placed in congress book.

INTRODUCTION

Humeral shaft fracture is the most common fracture type encountered in daily practice and the treatment options vary from conservative and surgical treatments. Many surgical techniques have been described in the treatment of humeral shaft fractures such as plate fixation, IMN, and external fixation, and these techniques have resulted in considerably high (>95%) union rates.[3-8] These fractures and surgical options are also associated with potential complications defined in the literature such as soft tissue damage, radial nerve palsy with plate screw fixation, and shoulder problems in IMN.[1,6,9-14]

Despite availability of various conservative and surgical treatment options with proven efficiency in the treatment of humeral shaft fractures, many factors such as increasing expectation for functional extremity in recent years, tendency toward minimally invasive surgery and cost analyses have contributed to the lack of agreement between orthopedic surgeons.[2]

METHODS

Patients

The study was carried out with the permission of Necmettin Erbakan University Meram Faculty of Medicine Non-Pharmaceutical and Non-Medical Device Researches Ethics Committee (Date: 13.02.2015, Decision No: 2015/112). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

In this retrospective study, a total of 62 patients who were admitted to Meram Medicine Hospital were analyzed. 3 patients for another fractures which affects scoring, 3 patients with pathological fracture, 4 patients had insufficent follow up, 8 patients under 18 age and 6 patients with concervative treatment of total 24 patients were excluded.

Cite this article: Pekince O, Koç MR, Toker S. Mid-term results in adult humeral fractures with titanium elastic nail fixation versus plate and screw fixation and locking intramedullary nailing. *J Orthop Res Rehabil.* 2023;1(1):11-15.

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RESULTS

The mean age (48.8 years) and duration of follow-up (19.3 months). 34.2% (n=13) females and 65.8% (n=25) males. Of the study participants had A3 (31.6%, n=12) and A2 (28.9%, n=11) type fractures according to the AO/OTA classification. Among all patients, four cortices union rate was 73.7% (n=28), 3 cortices union rate was 15.8% (n=6), and two cortices union rate was 5.3% (n=2), while one patient had one cortex union and nonunion. 50% of the fractures (n=19) were treated with plate fixation, 11 fractures (28.9%) with TEN, and eight fractures (21.1%) with IMN. The DASH scores, UCLA Shoulder scores, and Mayo and Stewart-Hundley scores are shown in Table 1.

Table 1: Hand, shoulder, and elbow scores

	Excellent	Good	Fair	Poor
UCLA	23(60,5%)	7 (18,4%)	2 (5,3%)	6 (15,8%)
MAYO	29 (76,3%)	6 (15,8%)	2 (5,3%)	1 (2,6%)
Steward-Hunley	24 (63,2%)	7 (18,4%)	6 (15,8%)	1 (2,6%)
	Mean±SD	**Median**	**Min**	**Max**
DASH	13,66±15,70	6,7	0	57,50

(DASH: Disability of Shoulder, Elbow and Hand)

In the assessment of postoperative extremity length, extremity shortness was more remarkable in the plate fixation group (4.2 mm). The mean length of hospital stay was higher in the plate and screw fixation group (10.5 days). Varus/valgus angles were higher in the TEN group (30, 70). The mean ranges of motion in the shoulder and elbow joints were more restricted in the IMN group (Figure 1).

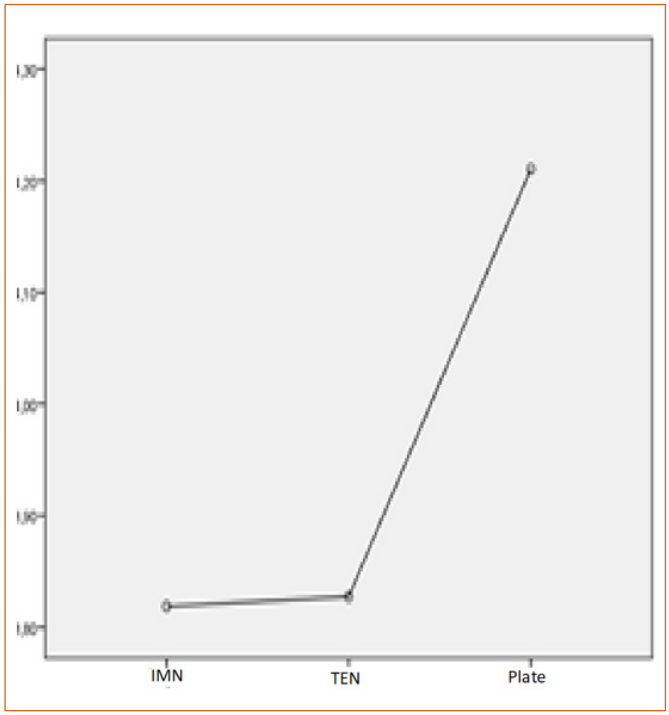

Figure 1. Mean shortness according to type of surgery

In the IMN group poor outcomes according to the UCLA score was than the others (50%). There was no good outcomes in the IMN group according to the MAYO; however, 20% of the patients had good outcomes in the other two groups. According to Steward-Hunley criteria the proportion of the patients did not significantly differ across the groups (Table 2).

Table 2. Distribution and relationship level of score according to type of surgery

Operation type	Locking IMN N (%)	TEN N (%)	Plate N (%)	p
UCLA				0.038*
Excellent	3 (37.5%)	6 (54.5%)	14 (73.7%)	
Good	1 (12.5%)	4 (36.4%)	2 (10.5%)	
Poor	0 (0%)	1 (9.1%)	1 (5.3%)	
Fair	4 (50%)a	0 (0%)b	2 (10.5%)	
MAYO				0.168
Excellent	6 (75	8 (72.7%)	15 (78.9%)	
Good	0 (0%)	2 (18.2%)	4 (21.1%)	
Poor	1 (12.5%)	1 (9.1%)	0 (0%)	
Fair	1 (12.5%)	0 (0%)	0 (0%)	
Steward-Hunley				0.421
Excellent	4 (50%)	9 (81.8%)	11 (57.9%)	
Good	1 (12.5%)	1 (9.1%)	5 (26.3%)	
Poor	2 (25%)	1 (9.1%)	3 (15.8%)	
Fair	1 (12.5%)	0 (0%)	0 (0%)	

There was no correlation between varus/valgus values and DASH (R=0.113, p=0.501). Varus/valgus angles were higher in patients with fair results in the UCLA. The patients with fair results in the MAYO had lowest angulation. Accordingly, it can be argued that increasing angulation negatively affects UCLA; however, angulation did not significantly affect the outcomes (Figure 2-4).

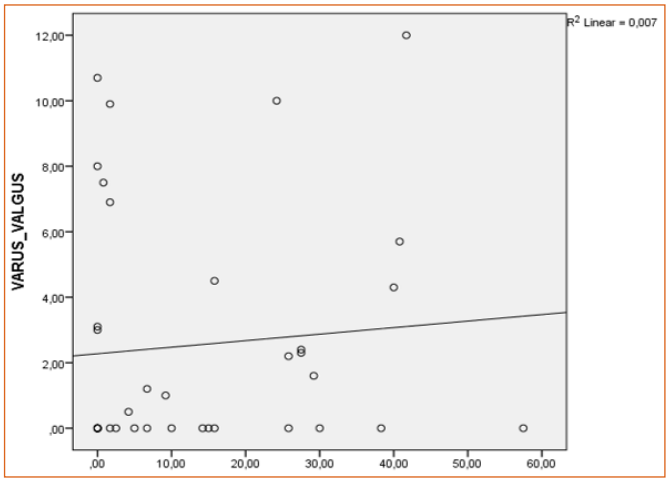

Figure 2. Relationship between DASH and Varus/Valgus

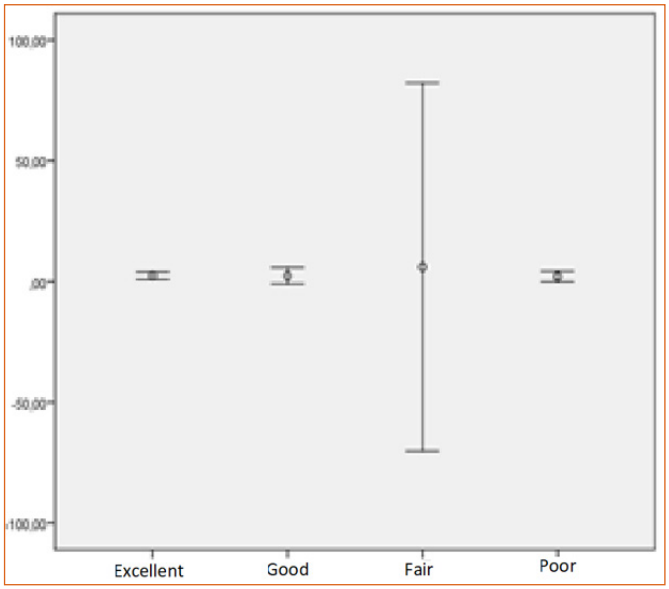

Figure 3. Relationship between UCLA and Varus/Valgus

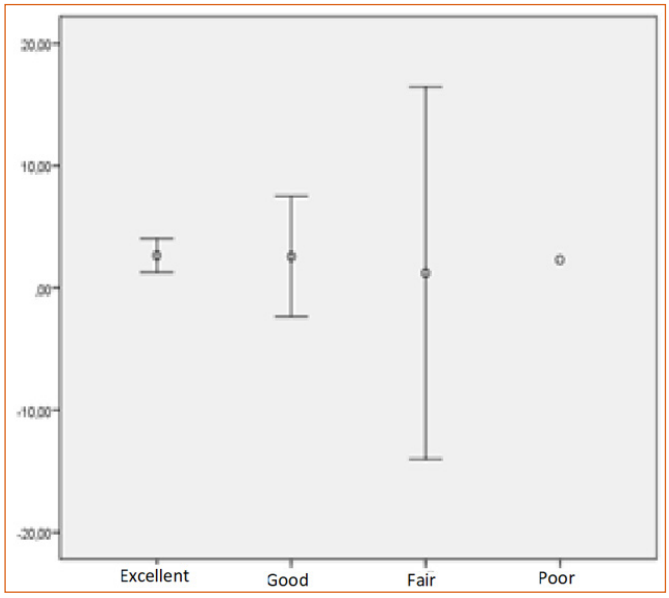

Figure 4. Relationship between MAYO and Varus/Valgus

No complications occurred in the majority of the patients 84.2%, n=32). The rate of radial nerve deficit before surgery did not differ between the groups, whereas radial nerve palsy in the postoperative period was observed only in the plate fixation group. During visits, two and three cortices union were more common in the plate groups, whereas four cortices union was high and close to each other. Infection occurred in three patients in the plate fixation group, whereas three patients in the TEN group with skin irritation.

DISCUSSION

Aim of this study is comparing the outcomes of TEN and other fixation methods in adult humeral diaphyseal fractures, and attempted to find an answer for whether it is possible to reduce soft tissue injury, shoulder problems, radial nerve injury and costs.

Humeral shaft fractures are the most common fractures in daily practice of orthopedicians.[1] Union is an important parameter of fractures. Merchan[3] reported a 95% union rate in patients with humeral fracture treated by plate fixation and IMN methods. Meekers[15] reported a union rate of 85% in the IMN and 100% in the plate fixation. In the study by Mc Cormak[16] the rate of nonunion was 4.3% in the plate and 9.5% in the IMN. Khurana[17] reported delayed union in two patients treated with 59 Ender nails. In 174 patients, Brug[8] used IMN in 84 patients, plate fixation in 58 patients, conservative approach in 9 patients, and monofixator in the remaining patients. The rate of nonunion was 1.2% in the IMN and 1.7% in the plate group. In a randomized prospective study of Chapman[13] used plate fixation in 46 patients and IMN in 38 patients. There was no significant difference between the groups. In another study Wali[18] published a prospective series of 50 patients comparing DCP plate fixation and IMN. There was two nonunion in each of the two groups up to 6 months after surgery. Kessler[7] suggested that in plate osteosynthesis caused extensive soft tissue damage so circulatory impairment and delayed healing. They also suggested that conservative treatment is associated with certain disadvantages such as inability to use affected arm for weeks, insufficient pain relief and self-care. Seidel nailing are good considering all these disadvantages. However due to the possibility of IMN's loosening and subacromial impingement syndrome; use of IMN is an alternative treatment in porotic bones and fresh fractures. Williams[19] reported union within a mean of six months in acute fractures and delayed union up to 12 weeks in one pathological fracture and five nonunion with Marchetti-Vicenci elastic nailing. Despite insufficient number of series that evaluated the outcomes of elastic nailing in humeral shaft fractures, they suggested that elastic nailing could be an option also in difficult humeral shaft fractures. The present study showed a union rate up to 98% and only one patient had nonunion. However, there was no significant difference between union rates of plate, IMN and TEN groups. The present study, therefore, used TEN fixation to decrease the discomfort of conservative therapy and to soft tissue injury with plate fixation and shoulder problems of IMN. As suggested by Williams we consider that TEN can be an important alternative option in humeral shaft fractures, although there is a paucity of published series in this regard.

Due to its proximity, radial nerve is important structure at risk of injury due to trauma and surgical technique. The prevalence of radial nerve palsy ranges from 6.6% to 8.5% in humeral shaft fractures.[6,10,11] Complete laceration or severe degeneration of the radial nerve after fracture has been reported to be 12 to 23%, whereas the rate of spontaneous recovery ranges from 73 to 92%.[20,21] Ekholm[12,22] reported that the prevalence of palsy was higher (14.5%) in the presence of "butterfly fragment". Wright[23] and Zuckerman[24] suggested that radial nerve paralysis occurs most frequently in fracture of the distal 1/3 of humerus. Foster[9] showed that permanent radial neuropathy was mostly caused by laceration or entrapment of nerve between the fragments. They highlighted that first signs of recovery of radial palsy after a mean of 7 weeks and complete recovery after 15 weeks, and electromyelographic evidences of recovery become prominent after 3-4.5 months. They did not recommend early exploration in closed fractures. They recommended surgical exploration during stabilization of the open fracture, primary repair in the nerve laceration, and reconstruction with nerve grafting 6 weeks after the lacerations caused by gunshot injuries. Shah[28] observed complete recovery before surgery in patients with Holstein-Lewis type fracture.

Kesemenli[6] reported radial paralysis in four patients with plate fixation and no paralysis in the IMN group. Osman[10] reported that radial injuries after treatment with IMN was lower than conservative treatment and plate fixation. There are also studies demonstrating higher rate of radial nerve deficit in patients treated with IMN.[6,12,16] In a prospective series of 50 patients reported by Wali[18] one patient in the IMN group and two patients in the plate fixation group developed radial paralysis. One of these patients underwent exploration and radial nerve was found to be entrapped under the plate. However, these conditions did not affect functional outcomes of the patients. In a review of 4,517 patients with humeral fracture reported by Shao[25] outcomes were similar between patients that underwent exploration eight weeks after and early exploration. In the present study four patients had radial nerve deficit before surgery. Of these patients, one had underwent IMN, one had underwent TEN, and two had underwent plate fixation. The patients treated with plate fixation underwent nerve exploration during surgery. Nerve palsy recovered in two patients in the early period after surgery, and two patients recovered within 6 to 8 weeks. These data suggest that early exploration may not be

appropriate unless there is solid evidence for full thickness or partial nerve injury, early or late exploration does not change functional outcomes, and exploration might be an unnecessary surgical intervention for a possibly reversible condition.

Varus is the most commonly observed angulation deformity in humeral shaft fractures.[26] Biomechanically, many different forces act on the humerus such as twisting and mediolateral bending have been reported to be the case of varus after humeral fracture.[27] Varus deformity may act as an unfavorable factor affecting healing of fractures, but it may also result in cosmetic problems.[28] Habernek[29] treated 19 patients using IMN. Four patients developed recurvature up to 5° and 3-10° varus deformity. Shoulder movements returned to normal up to 6 weeks and the patients returned to their usual activities within 6-10 weeks. The highest varus angulation in the present study was in the TEN group with a mean angulation of 4.46°. This finding was statistically significant, compared to the other groups, and these values were within the acceptable range for humeral diaphyseal fractures. In the assessment of angulation deformities affected the functional scores of the patients; relationship between scoring systems and varus/valgus rate was also not statistically significant.

Many studies reported higher rates of complications among with IMN such as shoulder problems.[6,18,19] In a study of 111 patients, Baltov1 reported 52 complications included distraction in the fracture, long proximal locking screw, and concurrent fracture. In the postoperative period, breakage of locking screw in 1 patient, proximal protrusion of IMN in 4 four patients, nonunion in one patient, and avascular necrosis of humeral head in two patients, and radial nerve deficit in one patient. Chapman[13] reported one reflex sympathetic dystrophy in the IMN group and three deep infection in the plate group. Six patients in the IMN group had shoulder pain, and six patients in the plate fixation group had elbow problems. Khurana[17] followed 59 patients treated with ender nails for a mean duration of 19 months. Fifty-three patients had angular deformity of less than 5° and six patients had a deformity between 5°-10°. The authors suggested that intramedullary elastic fixation has biological, mechanical and practical advantages and this method could be preferred in particularly elderly patients to avoid the risk of major surgery. Wali18 evaluated the outcomes of plate fixation versus IMN, the authors reported shoulder stiffness and pain in four patients in the IMN group and subacromial impingement in one patient, and the patient with impingement required removal of the implant. One patient in the IMN and 2 patients in the plate group developed superficial infection treated with oral antibiotics. One deep infection in the plate fixation group was treated with serial debridement and parenteral antibiotics. In the present study, skin irritation occurred in three patients in the TEN group, and TENs were removed upon union in these patients. Two superficial infection treated with oral antibiotics. Deep infection in one patient was treated with debridement repeated twice followed by removal of the implant. The fracture was treated with external fixator, and internal fixation was then performed after alleviation of infection. One patient treated with IMN developed varus deformity and nonunion. However, the patient rejected the offer to perform a second surgery.

Nonetheless, there are some limitations to this study. Retrospective design, small sample size, heterogen age group and short follow up groups are the main limitations.

CONCLUSION

Our study results suggest that TEN seems to be a good alternative treatment in eligible patients with humeral shaft fractures considering complications of other treatments such as soft tissue injuries, radial nerve problems of plate fixation, shoulder problems of IMN and comfort disadvantages of conservative methods. However, TEN is a new method on adult humeral shaft fractures as a traditional methods we believe that further, large-scale, randomized-controlled, prospective studies with longer follow-up duration are required to confirm these findings and to establish a definite conclusion.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Necmettin Erbakan University Meram Faculty of Medicine Non-Pharmaceutical and Non-Medical Device Researches Ethics Committee (Date: 13.02.2015, Decision No: 2015/112).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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